VOL. 1. NO. 5.

THE Sidereal Messenger.

Conducted by Wm. W. PAYNE,

Director of Carleton College Observatory.

AUGUST, 1882.

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"The voice that rolls the stars along
Speaks all the promises."

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XUM

The Sidereal Messenger.

"In the present small treatise I set forth some matters of interest to all observers of natural phenomena to look at and consider."—GALILEO, *Sidereus Nuncius*, 1610.

VOL. 1. AUGUST, 1882. No. 5.

THE WEDGE PHOTOMETER.*

BY EDWARD C. PICKERING.

Much attention has recently been directed to the use of a wedge of shade glass as a means of measuring the light of the stars. While it has been maintained by various writers that this device is not a new one, the credit for its introduction as a practical method of stellar photometry seems clearly to belong to Professor Pritchard, Director of the University Observatory, Oxford. Various theoretical objections have been offered to this photometer, and numerous sources of error suggested. Professor Pritchard has made the best possible reply to these criticisms by measuring a number of stars, and showing that his results agreed very closely with those obtained elsewhere by wholly different methods. His instrument consists of a wedge of shade glass of a neutral tint inserted in the field of view of the telescope, and movable so that a star may be viewed through the thicker or thinner portions at will. The exact position is indicated by means of a scale. The light of different stars is measured by bringing them in turn to the centre of the field, and moving the wedge from the thin towards the thick end until the star disappears. The exact point of disappearance is then read by the scale. The stars

*Presented to the Am. Acad. of A. &. S., May 10, 1882.

must always be kept in the same part of the field, or the readings will not be comparable. By a long wedge the error from this source will be reduced. A second wedge in the reversed position will render the absorption uniform throughout the field. Instead of keeping the star in the same place by means of clock-work, the edges of the wedge may be placed parallel to the path of the star, when the effect of its motion will be inseasible. To obtain the best results the work should be made purely differential, that is, frequent measures should be made of stars in the vicinity assumed as standards. Otherwise large errors may be committed, due to the varying sensitiveness of the eye, to the effect of moonlight, twilight, &c., and to various other causes.

A still further simplification of this photometer may be effected, by substituting the diurnal motion of the earth for the scale as a measure of the position of the star as regards the wedge. It is only necessary to insert in the field a bar parallel to the edge of the wedge and place it at right angles to the diurnal motion, so that a star in its transit across the field will pass behind the bar, and then undergo a continually increasing absorption as it passes towards the thicker portion of the wedge. It will thus grow fainter and fainter, until it finally disappears. It is now only necessary to measure the interval of time from the passage behind the bar until the star ceases to be visible, to determine the light. Moreover all stars, whether bright or faint, will pass through the same phases, appearing in turn of the 10, 11, 12, &c., magnitude, until they finally become invisible. For stars of the same declination, the variation in the times will be proportioned to the variations in the thickness of the glass. But since the logarithm of the light transmitted varies as the thickness of the glass, and the stellar magnitude varies as the logarithm of the light, it follows that the time will vary as the magnitude. For stars of different declinations, the times of traversing a given distance will be proportional to the secant of the declination. If δ, δ' are the declinations of two stars having magnitudes m and m', and t, t' are the times between their

transits over the bar and their disappearances, it follows that $m'-m = A\,(t \sec \delta - t' \sec \delta')$. For stars in the same declination calling $A \sec \delta = A'$ we have $m'-m = A'(t-t')$. Accordingly the distance of the bar from the edge of the wedge is unimportant, and, as in Professor Pritchard's form of the instrument, it is only necessary to determine the value of a single constant, A. Various methods may be employed to determine this quantity. Professor Pritchard has recommended reducing the aperture of the telescope. This method is open to the objection that the images are enlarged by diffraction when the aperture is diminished; constant errors may thus be introduced. Changing the aperture of a large telescope requires some time, and in the interval the sensibility of the eye may alter. These difficulties are avoided by the following method, which may be employed at any time. Cover the wedge with a diaphragm in which are two rectangular apertures, and place a uniformly illuminated surface behind it. Bring the two rectangles into contact by a double image prism, and measure their relative light by a Nicol. From the interval between the rectangles and the focal length of the telescope the light in magnitudes corresponding to one second, or A, may be deduced. Perhaps the best method with a small telescope is to measure a large number of stars whose light has already been determined photometrically, and deduce A from them.

The great advantage claimed for this form of wedge photometer is the simplicity of its construction, of the method of observing, and of the computations required to reduce the results. It may be easily transported and inserted in the field of any telescope like a ring micrometer. The time, if the observer is alone, may be taken by a chronograph or stop-watch. Great accuracy is not needed, since if ten seconds corresponds to one magnitude, it will only be necessary to observe the time to single seconds. The best method is to employ an assistant to record and take the time from a chronometer or clock. If the stars are observed in zones, the transits over the bar serve to identify or locate them as well as to determine their light. A wedge inserted in the

field of a transit instrument will permit the determination of the light of each star observed without interfering with the other portion of the observation. If the stars are all bright, time may be saved by dispensing with the thin portion of the wedge. In equatorial observations of asteroids the light may be measured photometrically with little additional expenditure of time. Perhaps the most useful application would be in the observations of zones. When the stars are somewhat scattered it would often happen that their light might be measured without any loss of time. By this instrument another field of usefulness is opened for the form of horizontal telescope advocated at a former meeting of this Academy (Proc. Amer. Acad. XVI. 364). Very perfect definition would not be required, since it would affect all the stars equally. To an amateur who would regard the complexity of an instrument as a serious objection to it, a means is now afforded of easily reducing his estimates of magnitude to an absolute system, and thus rendering them of real value.

DOUBLE METEORS.

BY LEWIS SWIFT.

Lieut. Maury's account of having seen a luminous connection or bridge between the two components of Biela's comet soon after their separation in 1846, which I have just read, brings freshly to my mind that on two occasions while sweeping for comets, I had seen a double meteor pass across the field of view. As I have never seen beside or read of such an occurrence, I desire to place them upon record as, possibly, having a certain amount of scientific value.

On the night of July 23, 1881, a double meteor, each being of about the brightness of a 7th magnitude star passed somewhat slowly across the center of the field of my comet eye-piece, from northeast to southwest. The pair was moving side by side with equal velocity, and, by estimation, was a little over a minute of arc apart. Neither appeared

to be in advance of the other. No luminous connection whatever was observed connecting the one with the other.

On Aug. 16, of the same year, and in the same constellation (Cepheus), I saw another pair moving in the same direction, which in every particular, save one, resembled the other; the exception being that there was a faint though easily seen luminous ligament of uniform size and brilliancy extending from the one to the other, resembling probably, (though on a smaller scale,) the luminous bridge Maury saw between the twin comets of Biela, only in the former case the band was straight, while in the latter it was curved.

The telescope therefore reveals the existence of double-stars, double comets, double nebulæ, and double shooting stars moving side by side through space.

During the twenty-two years in which I have been engaged in comet seeking, these are the only instances of my observation of double meteors, and I am anxious to learn if an analogous phenomenon has been observed by others.

This phenomenon suggests questions of the highest interest. Why the luminous bridge between them as though they had been connected by a physical tie during their journey of ages through space? It is supposed with a high degree of probability that the substances producing shooting stars are minute, solid particles, very properly named by Prof. Newton, meteoroids. It is quite easy to understand why they become luminous after plunging into our atmosphere, but in what manner the shining ligament was formed is a mystery indeed. If we suppose them to have been 50 miles distant and one minute of arc apart, it mathematically follows that they were not nearer together than a little over 750 feet. Can it for a moment be supposed that while in the meteoroid state, a solid inflexible arm like a dumb-bell 750 feet in length connected the two together, and that all three were simultaneously raised to incandescence? The liveliest imagination could hardly attain to such an idea. Persistence of vision will not explain it, as their line of direction was perpendicular to that of motion. The diameter of my field was $1\frac{1}{2}^{\circ}$.

Who can give a plausible explanation of the phenomenon?

ROCHESTER, N. Y., July 4, 1882.

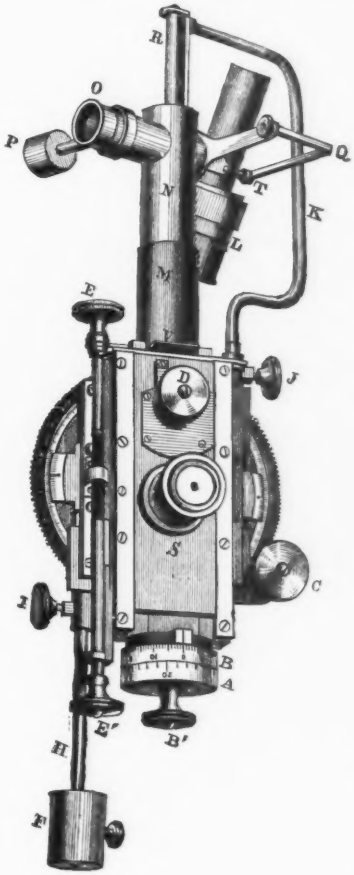
A NEW METHOD OF BRIGHT-WIRE ILLUMINATION FOR POSITION MICROMETERS.

BY S. W. BURNHAM.

In all my double-star measures I have uniformly used a bright-wire illumination, that method having been found by experience to be much superior to any form of bright field, and particularly in the observation of very close pairs and very faint companions which could only be seen with difficulty without any illumination at all. The Fraunhofer plan (which seems to have been the best in general use), of attaching the lamp to a hollow arm forming an angle of about 45° with the axis of the telescope, was always very objectionable and inconvenient, from the fact that to obtain a proper light on the wires it was necessary to change the place of the lamp with every change of the wires in position-angle, so as to allow the light to strike the wires approximately at right angles. For some years past I have given much attention, and made many experiments, with a view to the improvement of the micrometer in this respect. This resulted, while at the Washburn Observatory during the summer of 1881, in the execution of a plan for the "end" illumination of the Clark micrometer attached to the 15½-inch refractor of that Observatory. That device was fully described and illustrated in the *English Mechanic* for September 16, 1881. This micrometer was regularly used for some months, and although the illuminating apparatus was somewhat roughly made, and intended only to demonstrate the practical success of this device, it was found to work so satisfactorily in every respect that the micrometer for the 12-inch refractor of the Lick Observatory was constructed after the same plan, and was used by the writer for some weeks on Mount Hamilton, Cal., in the latter part of 1881. This illuminating apparatus is identical in principle with that previously described, but, as would be expected from the great skill and ingenuity of the firm of Alvan Clark & Sons, by whom it was made, the mechanical construction generally is vastly improved, and the

convenience and usefulness of the micrometer increased thereby.

The accompanying illustration is engraved from a photo-



graph of the Lick Observatory micrometer, the construction of which will be understood by a brief description.

The micrometer is of the usual form made by the Clarks,

B being the graduated head of the micrometer-screw, and A another graduated head turning on the same axis for giving the whole revolutions of the screw; C is the head of a pinion attached to the plate under the micrometer-box, and gearing into the teeth of the rigid circular plate containing the position-circle, for moving the wires in position-angle: D is the head of another small pinion for sliding the eye-piece over the wires: E E′ are heads of the bisecting-screw for moving the whole system of wires and the box S in a direction parallel to the micrometer-screw, and at right angles to the wires. The light from the lamp L is reflected by a mirror in N, and passes down that tube and through M, and then through a hole in the end of the box to the wires. A condensing lens is placed in N, for the purpose of concentrating the light on the wires. On the opposite side of the wires, towards the micrometer head, a small reflector is placed which reflects the light back, thereby symmetrically illuminating the wires on both sides. The lamp swings freely on its axis, in the line of OT, but always maintains a vertical position, whatever may be the direction of the wires or the pointing of the telescope. The tube N, with the lamp and its attachments, has an axle R supported by the fixed arm K. The bearings T, and axle of the lamp, are kept always horizontal by the weight of the counterpoise P. The tube M is fixed to the micrometer box, and projects loosely over N far enough to allow for the necessary movement of the box by the bisecting-screw E. The supporting arm K is attached by the set-screw J, not to the box, but to the plate underneath it, so that the weight moved by the bisecting-screw is not increased at all by the illuminating apparatus. Attached to the same plate, on the opposite side by a set-screw I, is the rod H, bent so as to be thrown forward out of the way of E′ and B, with a weight F to balance the weight of the lamp attachments. The whole device can be instantly detached when desired, by loosening the screws I and J. In the tube M is a slot V, in which is placed a slip of red or other colored glass, held in any desired place by a light spring pressing against it. All or any part of the light can be made to pass through

the colored medium. The mirror in N is attached to a tube which slides into the tube O. By turning this tube by the milled edge projecting at O, the inclination of the mirror may be varied to any extent, and the light reduced from the maximum amount until the wires become invisible. By turning the mirror 90° or more the light is entirely shut off. It will be seen that the lamp can revolve freely through the bent arm Q; and the whole moveable part of the device, lamp, arm Q, and counterpoise P, can turn through the supporting arm K, the lamp at all times remaining vertical, and in exactly the same position with respect to the wires. It might at first be supposed that the lamp, or some of the parts, would be in the way of the observer. I have never found it so in practice, and, although it is but a few seconds' work to either attach or detach it, I have very rarely removed it, whatever might have been the use of the telescope at the time.

It is important to preserve the relative positions of the micrometer-head, bisecting-screw, and pinion C, as here shown. No other arrangement will be as convenient. In every possible position of the micrometer, the necessary use of both hands at the same time will be found to be convenient and easy for the observer. Naturally the more delicate motions of the micrometer-screw and the pinion will be effected by the right hand, and the corresponding movement of the bisecting-screw by the left hand. When the micrometer box is anywhere near a horizontal position with respect to the observer (the wires at right angles to the line joining the eyes) C and E are used by the right and left hands respectively in measuring angles, and B′ and E in measuring distances. When the box is more nearly vertical with respect to the observer, the head E′ of the bisecting-screw will be worked by the left hand in each case. The convenience and practical value of this arrangement can only be appreciated by one who has used the old plans, and then tried this.

With respect to the practical working of the illumination, I will briefly say that it has proved a complete success in every respect. Any object that can be seen under

any circumstances, however faint, can be well and accurately measured. There is no such thing as a star too faint for measurement, if it can be seen at all. A very feeble light is sufficient to illuminate the wires perfectly for any object. I believe far better results can be obtained by the use of bright wires in a large part of the most desirable and important double-star work, than is possible by the same observer using a bright field, and that sooner or later it will be generally used in all micrometrical observations.

CHICAGO, February 25, 1882.

ON THE PHOTOGRAPHIC SPECTRUM OF COMET (WELLS) I., 1882.[1]

DR. WILLIAM HUGGINS, F. R. S.

On May 31, I obtained a photograph of the spectrum of this comet, with an exposure of one hour and a quarter. On the same plate I took a spectrum of α Ursæ majoris for comparison. The comet's spectrum on the plate consists of a strong continuous spectrum extending from about F to a little beyond H. I am not able to distinguish any of the Fraunhofer lines in this continuous spectrum. The slit was rather more open than was the case in photographing the spectrum of the comet of last year; this would make these lines less distinct, but the lines G and H are well seen in the star's spectrum taken under the same conditions. We may therefore conclude that the part of the comet's original light which gives a continuous spectrum is much stronger relatively to the reflected solar light in this comet, than was the case in the comet of last year, and for this reason the Fraunhofer lines are not distinguishable.

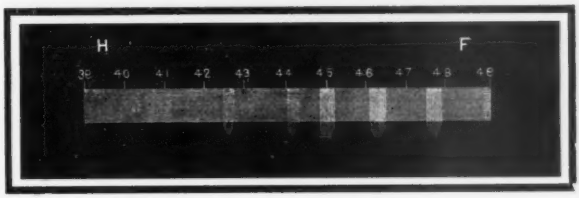
Observations of the visible spectrum had already shown that the comet differs remarkably from the hydro-carbon type common to all the comets, some twenty, which have appeared since spectrum analysis has been applied to these bodies.

The photographic spectrum shows, as was to be expected, that this essential difference of spectrum exists also in the

[1] Substance of note read before the Royal Society, June 15, 1882.

more refrangible region. The very strong ultra-violet group assigned to cyanogen is not to be seen on the plate, and the bright groups between G and *h*, and between *h* and H do not appear to be present.

The head of the comet was in sharp focus upon the slit, and the continuous spectrum with defined edges corresponds to the nucleus which in this comet was very distinct. In this continuous spectrum at least five separate places of greater brightness are seen, which very probably represent groups of bright lines, though they are not sufficiently distinct in the photograph to admit of resolution. That this interpretation is correct, seems probable, from the circumstance that these groups, as shown in the diagram, project



beyond the strong continuous spectrum on one side. This side corresponds to where the light of the coma, on the side of the nucleus next the sun, falls upon the slit. We learn, therefore, that the light of this part of the coma consists for the most part in this part of the spectrum of these groups, as here on the plate only an exceedingly faint continuous spectrum can be seen.

It is not possible to measure with any useful accuracy the beginnings and endings of the groups, as they are too faint at these points. Measures as accurate as the circumstances would permit have been taken of the brightest parts of the groups. The wave-lengths of these brightest

parts are: λ 4253, λ 4412, λ 4507, λ 4634, λ 4769

In the visible spectrum the bright lines of sodium appear

to have been strong, and it may be that some of the light of some of the groups may be due to this substance.

Prof. A. Herschel and Dr. von Konkoly showed long ago that the spectra of the periodic meteors are different for different swarms, and it does not seem surprising that we have now a comet, the matter of the nucleus of which under the sun's heat shows an essential chemical difference from the long series of hydrocarbon comets which have appeared since 1864.

Mr. Hind has kindly furnished me with the distance of this comet from the sun at the time the photograph was taken. The comet was then 42,380,000 miles distant from the sun, while the comet of last year was 69,420,000 miles when I obtained the photograph of its spectrum.

PRELIMINARY NOTICE OF THE RESULTS ACCOMPLISHED IN THE MANUFACTURE AND THEORY OF GRATINGS FOR OPTICAL PURPOSES.*

BY H. A. ROWLAND.

It is not many years since physicists considered that a spectroscope constructed of a large number of prisms was the best and only instrument for viewing the spectrum, where great power was required. These instruments were large and expensive, so that few physicists could possess them. Professor Young was the first to discover that some of the gratings of Mr. Rutherfurd showed more than any prism spectroscope which had then been constructed. But all the gratings which had been made up to that time were quite small, say one inch square, whereas the power of a grating in resolving the lines of the spectrum increases with the size. Mr. Rutherfurd then attempted to make as large gratings as his machine would allow, and produced some which were nearly two inches square, though he was rarely successful above an inch and three-quarters, having about thirty thousand lines. These gratings were on speculum metal and showed more of the spectrum than had ever before been seen, and have, in the hands of Young, Ruther-

*Extract from Johns Hopkins University Circular, No. 16.

furd, Lockyer and others, done much good work for science. Many mechanics in this country and in France and Germany, have sought to equal Mr. Rutherfurd's gratings, but without success.

Under these circumstances, I have taken up the subject with the resources at command in the physical laboratory of the Johns Hopkins University.

One of the problems to be solved in making a machine is to make a perfect screw, and this, mechanics of all countries have sought to do for over a hundred years and have failed. On thinking over the matter, I devised a plan whose details I shall soon publish, by which I hoped to make a practically perfect screw, and so important did the problem seem that I immediately set Mr. Schneider, the instrument maker of the university, at work at one. The operation seemed so successful that I immediately designed the remainder of the machine, and have now had the pleasure since Christmas of trying it. The screw is practically perfect, not by accident, but because of the new process for making it, and I have not yet been able to detect an error so great as one one-hundred-thousandth part of an inch at any part. Neither has it any appreciable periodic error. By means of this machine I have been able to make gratings with 43,000 lines to the inch, and have made a ruled surface with 160,000 lines on it, having about 29,000 lines to the inch. The capacity of the machine is to rule a surface $6\frac{1}{4} \times 4\frac{1}{4}$ inches with any required number of lines to the inch, the number only being limited by the wear of the diamond. The machine can be set to almost any number of lines to the inch, but I have not hitherto attempted more than 43,000 lines to the inch. It ruled so perfectly at this figure that I see no reason to doubt that at least two or three times that number might be ruled in one inch, though it would be useless for making gratings.

All gratings hitherto made have been ruled on flat surfaces. Such gratings require a pair of telescopes for viewing the spectrum; these telescopes interfere with many experiments, absorbing the extremities of the spectrum strongly; besides, two telescopes of sufficient size to use with six inch grat-

ings would be very expensive and clumsy affairs. In thinking over what would happen were the grating ruled on a surface not flat, I thought of a new method of attacking the problem, and soon found that if the lines were ruled on a spherical surface the spectrum would be brought to a focus without any telescope. This discovery of concave gratings is important for many physical investigations, such as the photographing of the spectrum both in the ultra-violet and the ultra-red, the determination of the heating effect of the different rays, and the determination of the relative wave lengths of the lines of the spectrum. Furthermore it reduces the spectroscope to its simplest proportions, so that spectroscopes of the highest power may be made at a cost which can place them in the hands of all observers. With one of my new concave gratings I have been able to detect double lines in the spectrum which were never before seen.

The laws of the concave grating are very beautiful on account of their simplicity, especially in the case where it will be used most. Draw the radius of curvature of the mirror to the center of the mirror, and from its central point with a radius equal to half the radius of curvature draw a circle; this circle thus passes through the center of curvature of the mirror and touches the mirror at its center. Now if the source of light is anywhere in this circle, the image of this source and the different orders of the spectra are all brought to focus on this circle. The word focus is hardly applicable to the case, however, for if the source of light is a point the light is not brought to a single point on the circle but is drawn out into a straight line with its length parallel to the axis of the circle. As the object is to see lines in the spectrum only, this fact is of little consequence provided the slit which is the source of light is parallel to the axis of the circle. Indeed it adds to the beauty of the spectra, as the horizontal lines due to dust in the slit are never present, as the dust has a different focal length from the lines of the spectrum. This action of the concave grating, however, somewhat impairs the light, especially of the higher orders, but the introduction of a cylindrical lens greatly obviates this inconvenience.

The beautiful simplicity of the fact that the line of foci of the different orders of the spectra are on the circle described above, leads immediately to a mechanical contrivance by which we can move from one spectrum to the next and yet have the apparatus always in focus: for we only have to attach the slit, the eye-piece and the grating to three arms of equal length, which are pivoted together at their other ends and the conditions are satisfied. However we move the three arms, the spectra are always in focus. The most interesting case of this contrivance is when the bars carrying the eye-piece and grating are attached end to end, thus forming a diameter of the circle with the eye-piece at the centre of curvature of the mirror, and the rod carrying the slit alone movable. In this case the spectrum as viewed by the eye-piece is normal, and when a micrometer is used the value of a division of its head in wave lengths does not depend on the position of the slit, but is simply proportional to the order of the spectrum, so that it need be determined once only. Furthermore, if the eye-piece is replaced by a photographic camera the photographic spectrum is a normal one. The mechanical means of keeping the focus is especially important when investigating the ultra-violet and ultra-red portions of the solar spectrum.

Another important property of the concave grating is that all the superimposed spectra are in exactly the same focus. When viewing such superimposed spectra it is a most beautiful sight to see the lines appear colored on a nearly white ground. By micrometric measurement of such superimposed spectra we have a most beautiful method of determining the relative wave lengths of the different portions of the spectrum, which far exceeds in accuracy any other method yet devised. In working in the ultra-violet or ultra-red portions of the spectrum, we can also focus on the superimposed spectrum and so get the focus for the portion experimented on.

The fact that the light has to pass through no glass in the concave grating makes it important in the examination of the extremities of the spectrum where the glass might absorb very much.

XUM

There is one important research in which the concave grating in its present form does not seem to be of much use, and that is in the examination of the solar protuberances; an instrument can only be used for this purpose in which the dust in the slit and the lines of the spectrum are in focus at once. It might be possible to introduce a cylindrical lens in such a way as to obviate this difficulty. But for other work on the sun the concave grating will be found very useful. But its principal use will be to get the relative wave lengths of the lines of the spectrum, and so to map the spectrum: to divide lines of the spectrum which are very near together, and so to see as much as possible of the spectrum; to photograph the spectrum so that it shall be normal; to investigate the portions of the spectrum beyond the range of vision; and lastly, to put in the hands of any physicist at a moderate cost such a powerful instrument as could only hitherto be purchased by wealthy individuals or institutions.

To give further information of what can be done in the way of gratings, I will state the following particulars:

The dividing engine can rule a space 6¼ inches long and 4¼ inches wide. The lines, which can be 4¼ inches long, do not depart from a straight line so much as 1-100000 inch, and the carriage moves forward in an equally straight line. The screw is practically perfect, and has been tested to 1-100000 inch without showing error. Neither does it have any appreciable periodic error, and the periodic error due to the mounting and graduated head can be entirely eliminated by a suitable attachment For showing the production of ghosts by a periodic error, such an error can be introduced to any reasonable amount. Every grating made by the machine is a good one, dividing the 1,474 line with ease, but some are better than others. Rutherfurd's machine only made one in every four good, and only one in a long time which might be called first-class. One division of the head of the screw makes 14,438 lines to the inch. Any fraction of this number in which the numerator is not greater than say 20 or 30, can be ruled. Some exact numbers to the millimetre, such as 400, 800, 1200, etc., can also

be ruled. For the finest definition either 14,438 or 28,876 lines to the inch are recommended, the first for ordinary use and the second for examining the extremities of the spectrum. Extremely brilliant gratings have been made with 43,314 lines to the inch, and there is little difficulty in ruling more if desired. The following show some results obtained:

Flat grating, 1 inch square, 43,000 lines to the inch. Divides the 1,474 line in the first spectrum.

Flat grating, 2×3 inches, 14,438 lines to the inch, total 43,314. Divides 1,474 in the first spectrum, the *E* line (Angstrom 5,269.4) in the second, and is good in the fourth and even fifth spectrum.

Flat grating, 2×3 inches, 1,200 lines to one millimetre. Shows very many more lines in the *B* and *A* groups than were ever before seen.

Flat grating, 2×3¼ inches, 14,438 lines to the inch. This has most wonderful brilliancy in one of the first spectra, so that I have seen the *Z* line, wave length 8,240, (see Abney's map of the ultra-red region), and determined its wave length roughly, and have seen much further below the *A* line than the *B* line is above the *A* line. The same may be said of the violet end of the spectrum. But such gratings are only obtained by accident.

Concave grating, 2×3 inches, 7 feet radius of curvature, 4,818 lines to the inch. The coincidences of the spectra can be observed to the tenth or twelfth spectrum.

Concave grating, 2×3 inches, 14,438 lines to the inch, radius of curvature 8 feet. Divides the 1,474 line in the first spectrum, the *E* line in the second, and is good in the third or fourth.

Concave grating, 3×5½ inches, 17 feet radius of curvature, 28,876 lines to the inch, and thus nearly 160,000 lines in all. This shows more in the first spectrum than was ever seen before. Divides 1,474 and *E* very widely and shows the stronger component of Angstrom 5,275 double. Second spectrum not tried.

Concave grating, 4×5¾ inches, 3,610 lines to the inch,

radius of curvature 5 feet 4 inches. This grating was made for Professor Langley s experiments on the ultra-red portion of the spectrum, and was thus made very bright in the first spectrum. The definition seems to be very fine, notwithstanding the short focus and divides the 1,474 line with ease. But it is difficult to rule so concave a grating, as the diamond marks differently on the different parts of the plate.

These give illustrations of the results accomplished, but of course many other experiments have been made. I have not yet been able to decide whether the definition of the concave grating fully comes up to that of a flat grating, but it evidently does so very nearly.

BALTIMORE, May 25, 1882.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

THIRTY-FIRST MEETING, TO BE HELD AT MONTREAL, CANADA, AUGUST, 1882.

The thirty-first meeting of the Association will be held at Montreal, Canada, commencing at 10 o'clock, A. M., on Wednesday, the 23rd of August, 1882: under the presidency of J. W. Dawson, LL. D., F. R. S., Principal of McGill University, Montreal. A large local committee has been formed, and through its several subcommittees is actively engaged in perfecting the local arrangements for the meeting, which will soon be announced by special circular. It is only necessary to state here that the members of the committee are desirous of doing everything in their power to promote the objects of the Association, and that their circular will contain information relating to the local arrangements, hotels and boarding-houses, and the special rates of transportation: also a general programme for the week.

Special invitations have been sent by the local committee to distinguish scientists abroad, and it is believed that several will be present.

The headquarters of the Association will be at McGill University, where members will register as soon as possible after arrival. The hotel headquarters will be at the Windsor.

The offices of the local committee and of the permanent secretary will be at the University. The general sessions and the meetings of the sections and committees will all be held in the University buildings. The particular rooms will be designated on the programmes for Wednesday.

Members expecting to attend the meeting are particularly requested to notify the local secretaries at the earliest moment possible.

At the Boston meeting several changes in the constitution were proposed, which were adopted at Cincinnati. As a result of these changes the scope of the Association has been extended, and the sections have been entirely reorganized, so that there are now nine sections of equal standing, each presided over by a vice president, and having its own secretary and sectional committee. The new arrangement of the sections is as follows:

Sec. A.—Mathematics and Astronomy. Sec. B.—Physics. Sec. C.—Chemistry, including its application to agriculture and the arts. Sec. D.—Mechanical science. Sec. E.—Geology and Geography. Sec. F.—Biology. Sec. G.—Histology and Microscopy. Sec. H.—Anthropology. Sec. I.—Economic Science and Statistics.

All communications relating to the local arrangements for the meeting must be addressed to one of the honorary local secretaries at the rooms of the Natural History Society, University St., Montreal.

All matters relating to membership and to the presentation of papers will be attended to by the permanent secretary, F. W. Putnam, Salem, Mass.

OFFICERS OF THE MONTREAL MEETING.

President—J. W. Dawson, of Montreal.

Vice Presidents—A. Mathematics and Astronomy—Wm. Harkness, of Washington. B. Physics—T. C. Mendenhall, of Columbus. C. Chemistry—H. C. Bolton, of Hartford. D. Mechanical Science—W. P. Trowbridge, of New Haven. E. Geology and Geography—E. T. Cox, of San Francisco. F. Biology—W. H. Dall, of Washington. G. Histology and Microscopy—A. H. Tuttle, of Columbus. H. Anthropology—Daniel Wilson, of Toronto. I. Economic Science and Statistics—E. B. Elliott, of Washington.

Permanent Secretary—F. W. Putnam, of Cambridge.

General Secretary—William Saunders, of London Ontario.

Assistant General Secretary—J. R. Eastman, of Washington.

Secretaries of the Sections—A. Mathematics and Astronomy—H. T. Eddy, of Cincinnati. B. Physics—Chas. S. Hastings, of Baltimore. C. Chemistry—Alfred Springer, of Cincinnati. D. Mechanical Science—Chas. B. Dudley, of Altoona. E. Geology and Geography—C. E. Dutton, of Washington. F. Biology—Charles S. Minot, of Boston. G. Histology and Microscopy—Robert Brown, Jr., of Cincinnati. H. Anthropology—Otis T. Mason, of Washington. I. Economic Science, and Statistics—F. B. Hough, of Lowville.

XUM

LIST OF NORTHERN STARS, USEFUL IN TIME DETERMINATIONS.

It is sometimes useful to have a list of stars north of 80° on which to reverse a portable transit instrument to determine the collimation. I give herewith a list of this kind, which was selected by Mr. COMSTOCK of this observatory, and which has been found to be of value.

All of these stars can be well observed with a bright field, in our FAUTH portable transit (aperture 3 inches power 120). Those stars marked with an asterisk have their apparent places given in the American Ephemeris.

	STAR.	M.	1882. R. A.	Dec.
			H. M.	
L. C.	B. A. C. 4150	6.5	12 13.2	87°6′
	Br. 48	6.5	0 30.6	81 47
L. C.	32 H Camel.	5.2	12 48.3	84 3
	43 H Ceph.	4.7	0 2.9	85 57
	*Polaris	2.1	1 55.5	88 41
	Rad. 521	6.8	1 11.4	81 22
L. C.	Gr. 2063	6.5	13 45.8	84 25
	Rad. 582	6.1	1 44.9	80 44
	B. A. C. 781	5.7	2 50.9	80 57
L. C.	Swd. 853	6.3	14 36.9	80 10
	B. A. C. 968	5.6	2 33.4	81 1
L. C.	B. A. C. 1082	5.8	11 58.1	83 0
	B. A. C. 960	5.8	3 51.6	84 29
	B. A. C. 1061	5.6	3 28.4	86 16
L. C.	Gr 2275	7.0	15 36.2	80 51
"	Rad. 3445	6.5	15 36.4	81 10
"	Gr. 2286	7.5	15 39.9	82 10
"	Rad. 3475	7.2	15 45.8	85 13
L. C.	18 Urs. Min.	6.7	15 76.2	80 21
	B. A. C. 1211	4.9	3 50.2	80 22
L. C.	Gr. 2315	7.3	15 56.0	83 18
	Rad. 1123	6.8	3 58.0	80 14
	Gr. 750	6.5	3 59.7	85 14
	Gr. 766	5.0	4 0.8	83 31
L. C.	Rad. 3523	7.5	16 1.3	85 39
	B. A. C. 1276	5.6	4 6.5	80 32
L. C.		7.3	16 8.9	80 57
		7.4	4 17.0	83 47
		7.7	4 28.2	84 40
	B. A. C. 1443	5.2	4 38.3	81 0
L. C.		7.2	16 36.4	83 58
L. C.		7.0	16 39.0	80 2
	Rad. 1311	6.0	4 49.8	85 18
	Ep'n Urs. Min.	4.3	16 58.1	82 14
	Rad. 1377	7.0	5 3.6	85 34
		7.1	5 7.1	83 45
	B. A. C. 1662	6.0	5 21.3	85 8
L. C.	Gr. 2456	6.2	17 28.35	80 14
"	Rad. 3749	7.1	17 32.3	81 43
"	Gr. 2476	7.5	17 35.3	83 26
L. C.	O. A. N. 17711	7.0	17 51.7	80 18
	Gr. 1004	7.0	6 0.0	86 56
L. C.	*D'ln Urs. Min	4.4	18 10.23	86 37
"	Y. 7789	7.5	18 11.7	85 11
L. C.	24 Urs. Min.	6.0	18 11.5	86 59
		7.2	6 13.2	80 39
		6.7	6 19.3	82 13

	STAR	M.	1882. R. A.	Dec.
			H. M.	
L. C.		7.2	18 21.2	81°25′
L. C.		7.5	18 25.3	82 53
		7.0	6 25.6	80 21
L. C.		7.5	18 28.0	84 36
"	Gr. 2708	7.4	18 39.1	83 17
L. C.	Gr. 2712	6.2	18 39.7	83 5
	*51 H Cephei	5.0	6 44.3	87 14
L. C.	Rad. 1208	7.0	18 53.6	86 33
		7.4	7 2.2	80 50
	P. vi 285	6.3	7 2.7	81 28
	Gr. 1259	5.3	7 6 2	82 38
L. C.	D. M. 572	6.0	19 6.6	82 12
L. C.	Rad. 4253	6.5	19 6.7	83 44
	Gr. 1278	6.6	7 12.9	81 8
L. C.	Rad. 4330	7.2	19 15.8	80 31
		7.5	7 23.9	81 57
L. C.	C. S.?	6.0	19 30.3	83 14
		7.2	7 35.3	81 39
	B. A. C. 2320	7.0	7 36 3	88 59
L. C.	*17da Urs Min	6.5	19 42.1	88 57
	B. A. C. 2585	5.8	7 48.5	84 24
	B. A. C. 2677	6.5	8 1.6	82 48
L. C.	24 H. Ceph	6.5	20 11.3	88 46
"	Rad. 4810	7.5	20 17.1	85 25
L. C	O. A. N. 20588	6.8	20 21.2	80 9
	Gr. 1431	7.0	8 24.7	82 39
L. C.	Gr 3260	7.0	20 26.8	84 10
L. C.	75 Draco	5.6	20 35.6	81 1
		7.0	8 38 1	83 10
L. C.	Rad. 4976	6.2	20 40 8	83 13
	Rad. 2218	6.0	8 50.3	84 39
L. C.	76 Draco	5.8	20 50 9	82 5
"	T. Y. C. 1879	5.3	20 53.0	80 6
"	O. A. N. 21950	7.0	21 9.0	80 42
"	" 23019	7.0	21 12.0	80 31
L. C.	Rad. 5218	6.5	21 17.1	80 18
	1 H Draco	4.3	9 20.9	81 51
	B. A. C. 7504	7.0	23 21.1	86 32
	Rad. 2404	6.5	9 49.5	84 29
		7.1	9 56.9	82 59
	Br. 1158	6.2	10 31.8	81 3
L. C.	B. A. C. 7980	4.9	22 47.9	82 14
"	B. A. C. 8026	5.0	22 55.3	87 43
"	" 8213	6.0	23 57.8	86 35
L. C.	" 8321	6.0	23 50 9	82 32
	" 4070	5.9	11 58.8	86 14

WASHBURN OBSERVATORY,
University of Wisconsin,
MADISON, 1882 June.

EDWARD S. HOLDEN.

CORRESPONDENCE.

THE WARNER PRIZES FOR ASTRONOMICAL RESEARCH.

So much extra research, resulting in valuable discoveries, was occasioned by reason of the prizes for astronomical discoveries of last year, that Mr. H. H. Warner of this city has concluded to continue the comet prizes during 1882, together with an additional prize for the discovery of meteors. Following is the offer, which we hope will stimulate as much exertion among both professional and amateur scientists as did that of last year, and hence be given a place in your columns. Sincerely, C. S. WHITTEMORE,

Secretary, Rochester Astronomical Society.

ROCHESTER, N. Y., 1882, May 9.

SCIENTIFIC PRIZES.

Mr. H. H. Warner, of Rochester, N. Y., has made the following offer to all discoverers of comets or meteors during the present year.

Warner Observatory, Rochester, N. Y., May 8, 1882.

The discoverers of four of the comets of 1881, having complied with all the conditions, were each awarded the Warner Comet Prize of two hundred dollars. Prof. Lewis Boss has also been paid the two hundred dollar prize awarded him by the judges for the best essay on comets.

Desiring to continue the prizes for scientific discoveries, I beg leave to announce, that for 1882, on or after this date, I will give three prizes, as follows, subject to the conditions named:

Prize First—Two hundred dollars in gold for each discovery of a new comet made in the United States, Canada, Great Britain or Ireland.

Conditions—1. It may be discovered either by telescope or the naked eye, but must be unexpected, except as to the comet of 1812, which may reappear during the year.

2. The announcement of the discovery must be made confidentially and exclusively (by telegraph) to Dr. Lewis Swift, director of the Warner Observatory, Rochester, N. Y., and to him alone, and he will cause the same to be immediately telegraphed, together with the name of the discoverer, to all parts of the world.

3. The telegram must give the time of discovery, position and direction of motion if possible, sufficiently exact to enable at least one other observer to find it. Three disinterested astronomers will be selected by Dr. Swift, to decide all disputed questions.

Prize Second—The sum of two hundred dollars, for any meteoric stone found in any of the above countries during

1882, which Prof. Henry A. Ward, of Rochester, N. Y., Principal Dawson of Montreal, Canada, and Prof. J. Lawrence Smith, of Louisville, Ky., shall unanimously decide contains fossil remains of animal or vegetable life, thus proving the inhabitability of other planets.

Prize Third—The sum of fifty dollars, for a specimen of any meteoric stone (whether it contain organic remains or not), seen to fall in the United States during 1882.

Condition.—A specimen (which shall become the property of the Warner Observatory) of not less than two ounces in weight, must be sent by mail to Dr. Swift, accompanied by a descriptive letter written in English, giving the time of its fall, weight of the entire stone, direction of flight, and such other facts regarding it as will be of value to science.

Most sincerely, H. H. WARNER.

THE WASHBURN OBSERVATORY.

[We take the liberty to insert the following extract from a letter to the editor. It is a brief description by a practical astronomer of an observatory which is taking high rank among American observatories, and of which the entire northwest may well be proud.—EDITOR.]

After seeing you at Chicago, I had a brief visit with Prof. Holden at the Washburn Observatory. I was exceedingly interested and pleased in looking over the observatory, not so much in the lovely situation and fine instrument (all of which I had expected), but in the many conveniences which have been introduced for facilitating work.

The arrangement for working the dome and shutters, the general mounting of the instrument, the division and numbering of the circles, the method of illumination (invented by Mr. Burnham), the arrangement for quickly lighting and darkening the room, are some of the many adaptations introduced to facilitate work. While any one of them may seem comparatively unimportant, the experienced astronomer knows that successful observing depends on careful attention to these details. For the purposes intended, the observatory seems to me the most perfect in the country, and shows the result of careful work and attention to details.

Prof. Watson had commenced a solar observatory mounted under the hill, and obtaining thus a dew cap of about 55

feet in length, to be used in searching for an intra-mercurial planet. This experiment is being continued by Prof. Holden, in accordance with the plans of Prof. Watson.

Since Prof. Holden has been in charge, a large amount of double-star work has been done. In addition to a large number of measures made, about 120 pairs of double-stars and 25 new nebulæ have been discovered by Prof. Holden, and 80 pairs of doubles by Mr. Burnham. The first volume of the observatory publications will be issued very soon.

The meridian circle is not yet mounted, but is expected in August; this will complete the instrumental outfit, and make the Washburn Observatory one of the most completely equipped in America. H. S. PRITCHETT.

EDITORIAL NOTES.

The WELLS comet, though very faint at last observation, is not without great interest. Twilight, moonlight, and unfavorable weather in the middle latitudes have made observation quite impossible since its re-appearance from behind the sun. June 12, Professor A. HALL of Washington, wrote that the comet was there last seen June 5, and that its brightness had been far less than the predictions had indicated. He also said that attempts to observe it in daylight at the upper culmination were not successful. By A. N. (2438) we learn, that Director J. F. J. SCHMIDT of the observatory at Athens, Greece, saw the comet by daylight with his telescope of 6.7 inches aperture, about five hours before perihelion passage, and obtained its position. Professor L. Boss of Dudley observatory, secured three meridian observations of the comet near perihelion, June 5.99, June 11 and 12, respectively, as given in *Science Observer*. At the first observation, the comet was exceedingly faint. June 11 and 12, the observations were entirely satisfactory, the comet appearing as bright as an eighth or ninth magnitude star at night. The coma was faint, but it had a central, round and sharply defined disk about three-fourths of a second in diameter. This observation was taken "sixteen hours after the epoch of a rarely close approach to the sun," the distance being only about 5,000,000 of miles as shown by three different computers. These observations are believed to be of great value, in that they give, at least one clear instance of the existence of a true nucleus. A full discussion of observations will be given as soon as generally received.

AUGUST EPHEMERIS.

Greenwich.	α (app)			δ (app)		
12^h	H.	M.	S.	°	′	″
Aug. 1.	11	52	43	5	08	36
5.	12	02	33	4	31	27
9.	12	11	35	3	56	27
13.	12	19	58	3	23	22
17.	12	27	47	2	51	59
21.	12	35	09	2	22	08
25.	13	42	08	1	53	41
29.	12	48	45	1	26	32
Sept. 2.	12	55	05	1	00	34

Dudley Obs., June 20, 1882.

At the last meeting of the Royal Astronomical Society of England, a full statement was given of the arrangements made for observation of the transit of *Venus* in December next. The English observers are planning to make less use of photography apparently than usual, giving attention chiefly to the observation of contacts. Parties of two observers each are to be sent to stations in Bermuda, Jamaica, Barbadoes, Madagascar, Brisbane, and New Zeland, at the expense of the home and colonial governments. Complete preparation is also being made for local observation at various points in Canada, Mauritius, Sydney, Melbourne of Australia and Cape of Good Hope. The English expect to have ten stations to act in concert in observing the egress. The West Indian and Australian stations give for a difference of the effects of parallax about 14^m. If the systematic error of these observations relatively to the others should not exceed 8^s or 10^s on certain contacts at different positions, the parallax attained will give the distance of the sun within one million of miles. If these observations agree relatively within 4^s, the sun's distance would be determined within 500,000 miles, the most accurate result now expected from this kind of work. It is to be hoped that American and European observers generally may so understand each other's ways of observing contacts, beforehand, that all may be certainly reduced to some common standard, if different in kind, thus securing the best possible results which the method will afford.

The British scientific expedition sent to the banks of the Upper Nile to make observations of the total eclipse of the sun, June 17, was every way successful. The chief members of the party were NORMAN LOCKYER, ARTHUR SCHUSTER, Mr. WOODS, Assistant, Mr. LAWRENCE and Mr. BLACK. The special correspondent to the London *Daily News* neatly summarizes the results as follows:

"This eventful morning was the finest we have yet had, cool and without a cloud. A great crowd of natives in picturesque costumes lined the road and the hill between the camp and Sohag. The shore of the Nile, except before the observatories, was packed with dahabiyehs bringing the governors of the provinces and other notables to

observe the eclipse and do honor to the strangers. Thanks to Moktar Bey, in charge of the camp, and a force of soldiery, there was no confusion. Along a line of three hundred yards, the French, English and Italian observers were left in undisturbed possession of tents and observatories. Nevertheless, while the sky darkened and assumed a leaden hue, the hills bounding the Nile bathed in purple, the great silence gave way, and from the river and palm-shaded slope arose a shout of wonder and fear, which reached its climax at the moment of the sun's disappearance, nor ceased then, for in addition to the horror of an eclipse—(which the nations here in India attribute to the act of a dragon)—there appeared in the heavens on the right of the sun an unmistakable scimetar. The eclipse had indeed revealed the existence of a new comet. Despite the short totality (one minute and twelve seconds) many valuable results have been obtained. I am permitted to send a copy of the collective telegram sent to the various governments, showing many new facts touching the sun's atmosphere, though matters have not become much simpler, which means more work. The layer to which much absorption has been ascribed seems vanishing from existence. The band K in the spectrum of the corona fully explains the eclipse coloring.

"Among the results, the most satisfactory are photographs of the corona, and a complete spectrum obtained by SCHUSTER on ABNEY'S plates. H and K are the most intense lines. A study of the red end of the spectrum of corona and protuberances was made by TACCHINI. A comet near the sun was a striking object, it was photographed and observed by the naked eye. Bright lines were observed before and after totality at different heights by LOCKYER, with intensities differing from FRAUNHOFER'S lines; by LOCKYER and TREPIED an absolute determination was made of the place of the coronal line 1474 in KIRCHHOFF'S scale; by THOLLON and TREPIED the absence of dark lines from the coronal spectrum was noted. TACCHINI and THOLLON with very different dispersions, noted many bright lines in the violet. THOLLON observed the spectrum of the corona, and SCHUSTER photographed it. The hydrogen and coronal line were studied in the grating spectroscope of BUISIEUX, and with direct vision prism by THOLLON. Rings were observed in the grating by LOCKYER, of the first, second and third order. The continuous spectrum is fainter than in 1878, stronger than in 1871. An intensification of the absorption lines was observed in group B, at the moon's edge, by TREPIED and THOLLON. The whole spectrum with blue lines on a continuous background has been photographed. Prominences photographed with the prismatic camera (showing, of course, ring spectrum). Three photographs were taken of the corona. The comet close to the sun was photographed with the prismatic and also ordinary cameras."

DANIEL KIRKWOOD has, for years, held the theory that there must be gaps or vacant spaces in the planetary zone between *Mars* and *Jupiter*. This hypothesis was suggested when the number of the minor planets was small, and hence it could in no way be verified. His reasoning was this, "If the *Sun* once exteaded to the outer limit of the Asteroid Zone, and the minor planets were originally separated from its equator, it is obvious that at the distance of 3.27, when the period would be one-half that of *Jupiter*, the perturbation by the latter planet would be extraordinary, gradually increasing the planetoid's eccentricity. Minor planets having this mean distance, or very near it, would thus in peri-

helion pass through the outer strata of the solar atmosphere. As a consequence of such motion in a resisting medium, some planetoids might be reincorporated with the central mass, while the orbits of others would gradually contract until the decreasing solar radius would leave them without further sensible resistance. Hence a chasm in the ring would be the obvious result." This theory is sustained by recent important French and English publications, from which the following facts are taken:

1. *The chasm at the distance* 3.37 has immediately interior to it a cluster of 37 small planets ranging between 3.07 and 3.22. The chasm is as wide as this planet belt, and does not contain a single asteroid. There are then seven minor planets beyond this hiatus.

2. *The distance* 2.50 *where the asteroid's period is one-third of Jupiter's.* Between the distances 2.425 and 2.475 there are sixteen planetoids. The space following this group containing the distance 2.50 is a complete gap, and five asteroids are found in a narrow exterior space.

3. *The distance* 2.82, *where five periods of an asteroid are equal to two of Jupiter.* Between the distances 2.753 and 2.803 there are twenty-one planetoids, and the next space of equal breadth containing the distance 2.82 there is but one. Following this vacancy, we find nine asteroids. Several other gaps have been noticed, but they are less distinct and simple. These facts are certainly very important.

The star ζ *Ursæ Minoris* was announced to be variable by STRUVE in 1838, and its change was supposed to be about half a magnitude, or from 2 to 2.5 magnitude. Other observers have, at times suspected its variability, but nothing more, until quite recently, the claim is again made by Mr. T. ESPIN of England. Mr. E. F. SAWYER of Cambridge observed this star April 30, May 1, 3, 6 and 7, and made it about half a magnitude fainter than α *Ursæ Minoris. Polaris* is also suspected of having slight variability. It is hoped that observers interested in this kind of astronomy will give these stars some attention, especially the first named.

Mr. SAWYER further reports that η *Ursæ Majoris* is possibly a variable star, with the short period of five days. The following observations of this star were recently made, using ε as a comparison star:

April 30, ε 4 steps $> \eta$

May 1, ε 4 " " "
" 3, ε 4 " " "
" 6, ε 2 " " "
" 7, ε 3 " " "

Five steps are counted equal to half a magnitude in the ordinary reckoning.

Olivet College, Mich., is considering the question of building an astronomical observatory.

HALSTED OBSERVATORY.

The new telescope at Princeton is now at last in position and nearly ready for work. It was made by A. CLARK & SONS of Cambridge, the glass disks being furnished by FEIL of Paris.

The diameter of the object-glass is 23 inches, and the focal length within an inch or two of 30 feet. At present its only superior in the United States is the 26-inch telescope of the Naval Observatory at Washington: in Europe the 27-inch refractor of the Vienna Observatory, and the 25-inch telescope of Mr. NEWHALL surpass it. Five other instruments of larger dimensions are indeed now constructing, two in Paris, and three in Cambridge; but it will be some time before any of them are finished.

In the Princeton telescope, the lenses which compose the object-glass are separated by a space of nearly seven inches, allowing a free circulation of air between them, and securing a rapid equalization of temperature. This construction also prevents the "ghosts" (formed by reflections between the lenses), which are very troublesome in some large instruments.

The spherical and color corrections are very fine in the Princeton telescope, and the performance of the object glass, so far as can be judged from a few nights' use, is entirely satisfactory. It is intended to devote the instrument for the present mainly to spectroscopic observations of the stars. The spectroscope is of CHRISTIE's direct vision form, which has been successfully used at Greenwich for several years. Mr. CHRISTIE (now Astronomer Royal) very kindly supervised its construction (by HILGER of London), and there is every reason to expect that it will prove a magnificent instrument. It is much larger and more powerful than anything ever used before in stellar work; it is nearly six feet long, and admits through the prisms a beam $2\frac{1}{4}$ inches in diameter.

A four horse power gas engine works the dome and shutters. It also drives one of EDISON's dynamo machines which furnishes a powerful current for purposes of illumination, and for producing the spectra of metals or gases to be compared with those of the stars. C. A. Y.

ALLEGHENY OBSERVATORY.

In a recent letter, Professor S. P. LANGLEY says:

"I am engaged on the reduction of the Mt. Whitney observations, and on related matters. The last work we have done at Allegheny is on the *infra* red spectrum which has been mapped within the past month (April), by the Bolometer to an extent never, I think, before reached, quite *through* the spectrum in fact, to the point where the earth's atmosphere absorbs all the solar heat. This point is found rather beyond that where wave-length is 30,000 in units of ANGSTROM's scale. On this scale the wave-length of the limiting visible line (A of FRAUNHOFER) is 7604. The maps include all the principal *cold* bands, most of which have been heretofore unknown. They are felt for, one

by one, with a linear Bolometer, first, in the spectrum of a prism, after, in that of a grating by which the wave lengths are determined. This research was described in its principal results, in a recent communication to the National Academy. It is connected with others whose object is the determination of the solar constant, and the discovery of the reason that the temperature of the earth's surface is so much higher than the direct solar radiation accounts for, as this latter (according to the Mt. Whitney observations) would not produce a temperature as high as 0° centigrade, under a tropical sun.

"This is the work of most general interest going on here at present, and I send in accordance with your request, this brief notice of it, in anticipation of its fuller publication."

YALE COLLEGE OBSERVATORY.

In a late report of Professor H. A. NEWTON, Director of Yale College Observatory, we learn that the Board of Managers are to proceed at once to erect suitable buildings on the observatory grounds, for the new Heliometer just received from Messrs. REPSOLD of Hamburg, and the new Equatorial Telescope, purchased of HOWARD GRUBB of Dublin, last summer. The towers for these instruments are now being erected, and the Heliometer is expected to be in place by the first of August, that the observers may have ample time to prepare for the best use of the instrument at the transit of *Venus* in December next. The new equatorial of eight inches aperture is expected from the makers about the middle of August, and it will also be ready for use early in the autumn. The domes for these instruments were made by Mr. GRUBB. The longitude of the transit house of this observatory was recently determined by exchanges of telegraphic signals on four nights by Prof. W. A. ROGERS of Cambridge and Dr. WALDO, an exchange of observers being made on two nights. The difference of longitude between the Meridian circle of Harvard College Observatory and the transit of Yale College is

$$0^{h}\ 7^{m}\ 10^{s}.353 \pm 0^{s}.0091.$$

This report also contains the second annual statement of Dr. WALDO, astronomer in charge of the horological and thermometrical bureaus of the observatory. This kind of work has not been undertaken any where else in this country; and although but fairly begun, a creditable showing is made.

NEW WINDSOR (ILLINOIS) OBSERVATORY.

This observatory (6-inch CLARK Equatorial) is engaged in making regular search for comets. To it has been assigned zone G, or that portion of the heavens between 0° and −15°. This space is swept each month to points near the sun as possible, reports of the work being sent at the close of the month to J. RITCHIE, Jr., *Science Observer*, Boston, Mass.

May and June were very unfavorable for observation, owing to clouds, rain and high winds. July has been better, but still no comets appear.

Indeed the year 1882 has thus far been below the average on comets, but one (WELLS') having put in an appearance. This has been observed since March 22, but we failed to behold the "conspicuous object" that was predicted, it not having attained a length of more than 2°. The sun is watched every clear day, a pleasant duty, also one that was amply repaid on April 16, when the solar upheaval occurred. The sun was in great agitation, while the large spot did not maintain the same form nor internal configuration so long as half an hour at a time during the day. All this was followed in the evening by a most remarkable and brilliant aurora. These things indicate that there exists a bond of union between solar and terrestrial phenomena, of whose nature it would be unwise to attempt to form an opinion in the present state of science. A lookout is kept up for variables, although none have been so far seen that were not already recorded. E. L. L.

THE LICK OBSERVATORY.

Work on the Lick Observatory has been resumed under the superintendence of Capt. FRASER. The temporary wooden tanks which hold the water supply after it has been pumped up from the springs, have been replaced by a large reservoir of brick and cement capable of holding 86,000 gallons. This is situated on the "middle peak," and is some 100 feet higher than "Observatory Peak" which has been cut down to a level surface. Thus a good pressure of water is available at the main observatory, and at the quarters, so that the possible dangers from fire, otherwise quite serious, are well guarded against.

The dome for the 12-inch CLARK equatorial is practically finished. The temporary canvas covering used in the observations of the transit of *Mercury* has been replaced by one of copper sheets, nickel-plated on the outside to reflect the sun's rays. The rolling gear for this dome (a live-ring of GRUBB'S plan) was made by WARNER & SWAZEY of Cleveland, and works to perfection. The piers for the CLARK photo-heliograph are begun, and it is expected that the brick and stone work of the ground floor will be largely completed by autumn. Capt. FLOYD, the president of the Lick Trustees, is on the ground, superintending the building, for which the plans were furnished by Professors NEWCOMB & HOLDEN. A sidereal clock by HOHWU of Amsterdam, is daily expected.

PARALLAXES OF SOUTHERN STARS.

Alpha Centauri, *Beta* Centauri, *Epsilon* Indi and Sirius are being observed at the Cape of Good Hope for parallax. Two observers, Mr. GILL and Dr. ELKIN, are making independent series on the four stars. Dr. ELKIN'S observations will be completed in Sept., 1882, and Mr. GILL'S in March, 1883. The work is done with Mr. GILL'S heliometer. Mr. GILL expresses his admiration for the new heliometer just made by the REPSOLDS for the Yale College Observatory, which he regards as the most perfect micrometric apparatus in the world. E. S. H.

SOLAR PARALLAX.

A letter recently received from Mr. GILL, Royal Astronomer at the Cape of Good Hope, states that so far, only one American observatory has expressed a willingness to co-operate with the Cape observatory in his scheme of observations of *Victoria* and *Sappho* for determination of the Solar Parallax. Mr. GILL is about to issue a programme of comparison stars to be observed with these asteroids on the meridian, and to ask for observations from American observers. E. S. H.

DUN ECHT CIRCULAR.

The spectrum of the nucleus of Comet WELLS deserves the closest attention, as it shows a sharp bright line coincident with D as well as strong traces of other bright lines, resembling in appearance those seen in the spectra of γ *Cassiopeiæ* and allied stars.

RALPH COPELAND,
J. G. LOHSE.

Lord Crawford's Observatory, Dun Echt, 1882, May 29.

NEW OBSERVATORY AT TASHKENT.

A new observatory has been founded at Tashkent, under the direction of Lieut. POMERANTZEFF. The principal instruments are—

1. A REPSOLD Meridian Circle, of 4.82 inch aperture, and 55.27 focus, with a circle divided to 2′ and read by 4 microscopes.
2. A MERZ equatorial of 6.34 inches aperture.
3. A Sidereal clock by HOHWU.

The geographical position is:

Latitude, $40^{\circ}\ 18'\ 32''.2$.

Longitude, $2^{h}\ 35^{m}\ 52^{s}.15$, east of Pulkova.

TRANSIT OF VENUS, 1882.

A note from Dr. AUWERS (A. N. 2435) gives the selection of the German transit of *Venus* stations as follows:

I. Hartford, Connecticut.
II. Aiken, South Carolina.
III. Bahia Blanca, Argentine Republic.
IV. Punta Arenas, Straits of Magellan.

Each expedition will have a FRAUNHOFER heliometer (about 3 inches aperture), and two 6 feet equatorials. The observations will be made on the same programmes as those of 1874. All the stations will observe all possible occultations of stars at the dark limb of the moon (immersions and emersions), and Dr. AUWERS asks all observatories to aid in observing such occulations between October 1, 1882, and February 1, 1883. E. S. H.

THE VARIABILITY OF RED STARS.

In a recent paper presented to the Saint Petersburg Academy of Sciences, Dr. LINDEMANN of Pulkova has investigated the effect of the

red colors of stars on estimates of their magnitudes. His observations have been made with a ZOELLNER's photometer, and he has compared the results of ROSEN & WOEFF with his own. This is not the place to indicate his methods, which indeed are laid down in ZOELLNER's well-known work; but we may quote his general conclusion to the effect that in matching an artificial star produced by the photometer, with a red star, the accidental errors are very great compared to similar comparisons with white stars, and that in general the sensibility of the eye to red rays is 3 or 4 times less than to blue. The errors may amount to at least one magnitude, and we should look with doubt upon red variable stars where the variability is less than a magnitude or so.

E. S. H.

The sidereal clock ordered by the Lick trustees, from A. HOHWU of Amsterdam, has arrived in this country. It is in all respects similar to the normal clock of the Washburn observatory, described in its publications, Vol. I., 1881, page 12; and to a clock just delivered to the Pulkova observatory. Its cost is about $447.00. Similar clocks are mounted at the observatories of Leyden, Strassburg, Brussels and Tashkent. This clock bears the number, 33. E. S. H.

E. E. BARNARD of Nashville, Tenn., has discovered a new nebula in

$$\alpha \quad 14^{h}\ 16\tfrac{1}{4}^{m}$$
$$\delta \quad +\ 0^{\circ}\ 13' \pm$$

He says it is a faint object in his five-inch telescope, precedes a 7th magnitude star by 16^{s}, and is north of the star 16$'$. Professor SWIFT has examined it, and says that it appears mottled, and as though more light and power would resolve it. This nebula was discovered in July, 1881, but Mr. BARNARD did not know that it was new until quite recently.

PERSONAL.

C. PIAZZI SMYTH, Astronomer Royal of Scotland, was the first foreign subscriber to the SIDEREAL MESSENGER.

A new minor planet of the twelfth magnitude (No. 225) was discovered by J. PALISA of Vienna, July 22, 1882.

Observer F. HESS of Iowa City, is making complete and important arrangements for observing the transit of *Venus*. A description of his plan of work will appear soon.

S. W. BURNHAM of Chicago, spends some of his leisure hours in the practice of photography, taking views both celestial and terrestrial. Some of his late instantaneous pictures show excellent definition.

Professor HOUGH, of Dearborn Observatory, is working on a piece of new astronomical apparatus that promises to be of great value to the working astronomer. Something more definite will probably soon appear.

The new observatory at Beloit College is nearing completion. Professor SMITH expects to have it ready for work early in September. The instrumental outfit will be excellent and complete for the purpose of instruction.

Professor H. A. Howe, of the University at Denver, Colorado, and formerly of Cincinnati Observatory, is making a summer visit at his home in Chicago. He has just completed important parts of WENTWORTH'S new Algebra, soon to be published.

The degree of LL. D. was conferred by the University of Wisconsin upon two astronomers, at the annual commencement in June, viz.: Professor HENRY DRAPER and Prof. S. P. LANGLEY. The University could not have selected two names more honorable to its list of special degrees.

Mr. JOHN A. BRASHEAR of Pittsburgh, Pa., maker of silvered-glass reflecting telescopes and specula, has recently issued a neat little pamphlet, that is full of valuable information respecting the structure and care of reflecting telescopes. His advertisement elsewhere gives his particular address.

The University of Virginia is located near Charlottesville, in Albemarle county. Late reports show rapid advancement in its scientific endowments. The foundation of the LEANDER MCCORMICK observatory has been laid. Professor STONE, the director, is enjoying a vacation with his family in the mountains of Virginia.

JOHN HAGEN, S. J., College of the Sacred Heart, Prairie Du Chien, Wis., in February last, read a very valuable paper before the American Philosophical Society, "On the inclination of the apparent to the true horizon, and the errors arising therefrom to transit, altitude and azimuth observations. Fuller notice of it will be given later.

Mr. JOHN BYRNE of the City of New York, well known maker of refracting telescopes, lately furnished us a list containing the names of persons, and the places where thirty telescopes of his own recent make are now in use. The record is an excellent one. This entire list will be incorporated in our table of American telescopes soon to be revised and published.

Assistant H. C. WILSON of the Cincinnati Observatory, recently spent a few weeks visiting friends at his home in southern Minnesota. In June last, he received the Master's Degree from Carleton College. The thesis required for the diploma was on the theme, "The physical characteristics of Wells comet, the computation of its orbit and an ephemeris for at least one month after its perihelion passage." Mr. WILSON is acting director at Cincinnati since Professor STONE'S resignation, a very unusual honor for so young a man as he.

XUM

Dr. L. WALDO of Yale College Observatory, by telegram recently, brought us face to face, in Chicago, unexpectedly, with our excellent friends, Prof. E. S. HOLDEN, of Madison, and Prof. H. S. PRITCHETT, of St. Louis. The surprise to all was complete, and, we think, regarded as a piece of pleasantry highly enjoyable; and all the more so, as we found ourselves the honored guests of Mr. M. F. TYLER, President of the New Haven Standard Time Company, at the Palmer House. The theme of conversation was standard-time for the Southwest and the Northwest.

BOOKS.

1. Algebra for Schools and Colleges, second edition, Revised, pp. 399.
2. Elements of Geometry, pp. 470.
3. Elements of Plane and Spherical Trigonometry with Logarithmic and other Mathematical Tables, and examples of their use, and hints on the art of computation, pp. 269.

All by Simon Newcomb, Professor of Mathematics, United States Navy, New York, Henry Holt & Company Publishers, 1882.

The algebra of this series furnishes about the course of study used in the best colleges and scientific schools at the present time; it is in two parts, the first, intended to prepare students to enter college, and the second is an advanced course, designed for the more general student. In method, free use is made of the concrete form, the author believing that the youthful mind has need of such aid to grasp ideas fully and certainly. Numerical examples are therefore more commonly used than in similar works by other writers; and this certainly accords with the practice of skillful mathematicians who usually resort to numbers to assist their minds in the comprehension of unfamiliar or complex relations, especially of imaginary quantities. The author also thinks that better results would be realized, if the teaching of advanced algebra and geometry were simultaneous, instead of successive, as is generally the case. The course in algebra would then include the calculus, and the analytic course, so called, would comprise geometry, plane and general, and trigonometry. One scheme would furnish the methods of work, the other, the applications; a method of instruction at once natural and effective. Some teachers are pursuing that plan most effectively, but ill-arranged text-books are a hinderance to it.

The plan of the geometry is mainly that of Euclid and eminent writers following him. The definitions and principles are based on the fundamental concepts of geometry as modified by modern research, especially among German mathematicians. Some of the most prominent of these are, that geometry has its foundation in observation; that points, lines, surfaces and solids are to be regarded as attaching to material bodies, rather than as formed of mere space; that the mode of generating magnitudes should be distinguished from the definitions of the same; and that the idea of angular magnitude should be extended beyond 180° without a change in the nature of the concept. The treat-

ment of proportion is full and carefully particular as its importance deserves. If an outline study of conic sections is to be taken independent of analytical geometry, the graphic method of course only remains, by which to pursue it, and the merest introduction to this prolific field of study is all that can be expected. The student will not get one hint of the beautiful and elegant methods and results furnished by general and infinitessimal analysis. The chapter on the limits of figures, though new in such a book, is logically in place, and it is hoped will hereafter be esteemed a necessary part of elementary instruction in geometry.

The trigonometry of this series is excellent. It is complete, fresh and thorough for the use of the class-room. It also has very much of practical suggestion, which makes it a useful hand-book for the working mathematician. Although the scope of the work is generally limited to the subjects usually taught in a full course of mathematics in colleges and scientific schools, yet the concluding chapter of the first part goes further and presents a development of trigonometric forms of imaginary quantities with interesting results. In the second part, devoted to spherical trigonometry, there is also a similar advanced step taken, in which the student is introduced to practical exercises in the higher forms of solid geometry. The tables are evidently prepared by an expert, for they are easily and quickly read. The publisher's part in all these books is handsomely done.

A Treatise on Astronomy, Spherical and Physical; with Astronomical Problems, and Solar, Lunar and other Astronomical Tables, for the use of Colleges and Scientific schools, by William A. Norton, M. A., Professor of Civil Engineering in Yale College. 5th Edition, Revised and Enlarged. New York, John Wiley & Sons, 15 Astor Place, 1882. pp. 457. Tables and illustrations, pp. 130.

Nothing needs to be said of the merits of Norton's Astronomy, as it has appeared in previous editions in past years, for the work has been widely used and favorably known. The last edition, bearing date February 15, of the present year, embodies all the recent determinations, discoveries, and researches that may come profitably within the range of a college text-book, for a complete or liberal course of study in this most enjoyable science. The important results respecting the constitution of the heavenly bodies, obtained by aid of the spectroscope, polariscope, and other modern instrumental applications, receive due attention. In the appendix are found extended notes giving late information and the most approved theories that plausibly stand the tests of the practical part of the science. The mathematical part of this book is so complete as to place it among the first of college text-books, and the student that will patiently master it, will have a clearer insight into the principles of the science than any amount of mere reading or plainly-worded description can possibly furnish. The geometrical figures are good, but the cuts representing physical characteristics in the text are not quite equal to the standard of the work in other respects. The formulæ and tables at the end of the book are convenient, complete and useful, and the illustrations there are neatly engraved.

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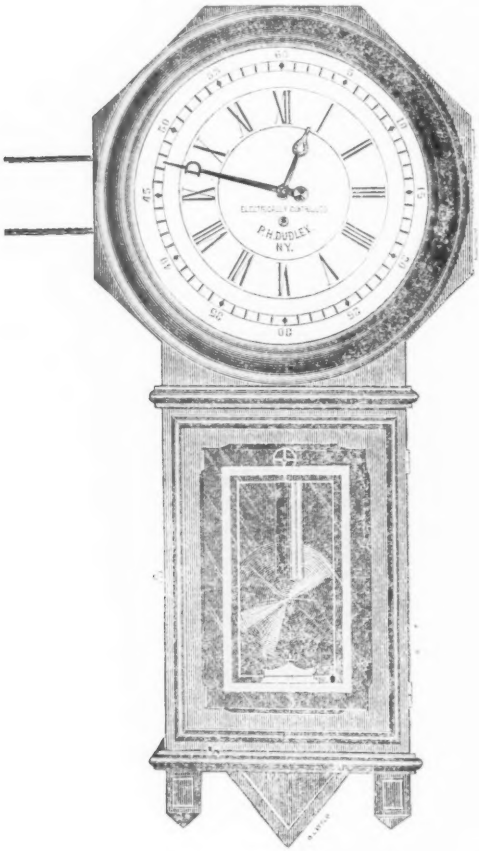

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